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(71) Applicant: **TOSHIBA CORP**

(72) Inventor: **Kaichi FUKUDA**

(54) [Title of Invention]

THIN FILM TRANSISTOR, MANUFACTURING METHOD THEREOF AND LIQUID CRYSTAL DISPLAY ELEMENT

(57) [Abstract]

[PURPOSE] To provide a thin film transistor having excellent characteristics, stability, insulatability, yield and processing matching property.

[CONSTITUTION] A gate electrode 2 is formed on one main surface of a glass substrate 1. A silicon oxynitride (SiO_xN_y) film 3a and silicon nitride (SiN_x) film 3b are laminated to form on the gate electrode 2, and a gate insulating film 3 is formed by these two layers. An a-Si film 4 is laminated to form on this gate insulating film 3. An SiN_x film is laminated on the a-Si film 4 to form a channel protective film 5. A pixel electrode 7 consisting of ITO (Indium Tin Oxide) is formed on the gate insulating film 3. A source electrode 8 is formed on the source region of a low-resistance semiconductor film 6 in the state of connecting this electrode to the pixel electrode 7, a drain electrode 9 is formed on the drain region, a protective film 10 is laminated to form, so as to obtain an active element substrate 12.

[Claims]

[Claim 1] In a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized by forming the aforementioned gate insulating film in the laminated films of an acid silicon nitride film and a silicon nitride film, and this silicon nitride film being in contact with the aforementioned non-single crystal silicon.

[Claim 2] A thin film transistor according to Claim 1 characterized in that: an acid silicon nitride film mainly contains Si, N, O and H, wherein the concentration of N ranges from 0.1 to 0.8 at N/Si ratio and less than the concentration of O; and a silicon nitride film mainly contains Si, N and H, wherein the concentration of N ranges from 1.2 to 1.6 at N/Si ratio and the concentration of O is less than 5×10^{20} atoms/cm^3.

[Claim 3] A thin film transistor according to Claim 1 or 2 characterized by doping any one of P or B into at least one part of an acid silicon nitride film.

[Claim 4] A thin film transistor according to any one of Claims 1 to 3 characterized in that a refractive index of an acid silicon nitride film ranges from 1.49 to 1.65 at wavelength of 632.8 nm.

[Claim 5] A thin film transistor according to any one of Claims 1 to 4 characterized in that: a thickness of an acid silicon nitride film ranges from 200 nm to 450 nm; and a thickness of a silicon nitride film ranges from 5 nm to 200 nm.

[Claim 6] In a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon.

[Claim 7] A thin film transistor according to Claim 6 characterized by doping any one of P or B into at least one part of a silicon nitride film.

[Claim 8] A thin film transistor according to Claim 6 or 7 characterized in that a silicon oxide film mainly contains Si, O and H, wherein the concentration of N is less than 5×10^{20} atoms/cm^3.

[Claim 9] A thin film transistor according to any one of Claims 6 to 8 characterized in that: the total thickness of a silicon oxide film and an acid silicon nitride film ranges from 200 nm to 450 nm; and a thickness of an acid silicon nitride film is more than 100 nm; and a thickness of a silicon nitride film ranges from 5 nm to 200 nm.

[Claim 10] In a thin film transistor which uses non-single crystal silicon for an active layer that is formed on a gate insulating film formed on a gate electrode, and has an

inverted staggered structure with a channel protective film, it is characterized in that: a gate insulating film is formed in the laminated films of an acid silicon nitride film and a silicon nitride film; and this silicon nitride film is in contact with the aforementioned non-single crystal silicon; and the aforementioned channel protective film is self-matched to the aforementioned gate electrode.

[Claim 11] In a thin film transistor which uses non-single crystal silicon for an active layer that is formed on a gate insulating film formed on a gate electrode, and has an inverted staggered structure with a channel protective film, it is characterized by forming the aforementioned gate insulating film in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film being in contact with the aforementioned non-single crystal silicon; and self-matching the aforementioned channel protective film to the aforementioned gate electrode.

[Claim 12] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized by: forming the aforementioned gate insulating film in the laminated films of an acid silicon nitride film and a silicon nitride film; this silicon nitride film being in contact with the aforementioned non-single crystal silicon; and forming this an acid silicon nitride film by the plasma CVD using a mixed gas of SiH_4, N_2O, N_2 or NH_3 as a material gas.

[Claim 13] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized by: forming the aforementioned gate insulating film in the laminated films of an acid silicon nitride film and a silicon nitride film; this silicon nitride film being in contact with the aforementioned non-single crystal silicon; and forming the aforementioned acid silicon nitride film by the plasma CVD using a mixed gas of organic silane, O_2, N_2 or NH_3 as a material gas.

[Claim 14] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized by: forming the aforementioned gate insulating film in the laminated films of an acid silicon nitride film and a silicon nitride film; this silicon nitride film being in contact with the aforementioned non-single crystal silicon; and forming the aforementioned acid silicon nitride film, silicon nitride film and non-single crystal silicon in the same reaction chamber of the plasma CVD successively.

[Claim 15] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, and a protective film

using an inorganic insulating film is formed on the surface, it is characterized by: forming the aforementioned gate insulating film in the laminated films of an acid silicon nitride film and a silicon nitride film; this silicon nitride film being in contact with the aforementioned non-single crystal silicon; and forming the aforementioned acid silicon nitride film, silicon nitride film, non-single crystal silicon and inorganic insulating film in the same reaction chamber of the plasma CVD successively.

[Claim 16] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; the aforementioned silicon oxide film uses SiH_4 and O_2 as a main material gas using N_2 for a dilution gas; to form by the ordinary pressure CVD.

[Claim 17] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; the aforementioned silicon oxide film uses organic silane, O_2, N_2 and NH_3 as a main material gas using N_2 for a dilution gas; to form by the ordinary pressure CVD.

[Claim 18] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; the aforementioned silicon oxide film uses SiH_4 and N_2O as a main material gas; to form by the plasma CVD.

[Claim 19] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon;

the aforementioned silicon oxide film uses organic silane and O_2 as a main material gas; to form by the plasma CVD.

[Claim 20] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film on a substrate, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; and a substrate that the aforementioned silicon oxide film is formed is annealed in the vacuum of 10 Torr or less than or in the reduced pressure ambient atmosphere; and then an acid silicon nitride film is formed without exposing into the atomospheric air.

[Claim 21] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film on a substrate, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; and the aforementioned acid silicon nitride film, silicon nitride film and non-single crystal silicon are formed in the same reaction chamber of the plasma CVD successively.

[Claim 22] In a manufacturing method of a thin film transistor which uses non-single crystal silicon for an active layer formed on a gate insulating film on a substrate, and a protective film using an inorganic insulating film is formed on the surface, it is characterized in that: the aforementioned gate insulating film is formed in the laminated films of a silicon oxide film, an acid silicon nitride film and a silicon nitride film; this acid silicon nitride film is arranged covering the upper part of the aforementioned silicon oxide film; this silicon nitride film is in contact with the aforementioned non-single crystal silicon; and an acid silicon nitride film, a silicon nitride film, a non-single crystal silicon and an inorganic insulating film are formed in the same reaction chamber of the plasma CVD successively.

[Claim 23] A liquid crystal display element characterized by using a thin film transistor according to any one of Claims 1 to 11 as a switching element.